CALFED

TECHNICAL REPORT
ENVIRONMENTAL CONSEQUENCES

FLOOD CONTROL

DRAFT

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CALFED
BAY-DELTA
PROGRAM

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LIST OF ACRONYMS

BDOC	Bay-Delta Oversight Committee
CALFED	CALFED Bay-Delta Program
CEQA	California Environmental Quality Act
cfs	cubic foot per second
Corps	U.S. Army Corps of Engineers
CVP	Central Valley Project
DWR	California Department of Water Resources
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ISDP	Interim South Delta Program
MAF	million acre-feet
NEPA	National Environmental Policy Act
PL	Public Law
Reclamation	U.S. Bureau of Reclamation
SB	Senate Bill
SWP	State Water Project
TAF	thousand acre-feet
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

FLOOD CONTROL SYSTEM

INTRODUCTION

This technical report discusses impacts on flood control associated with implementation of the CALFED Bay-Delta Program (CALFED).

The following components of flood control are discussed:

- Flood management operations,
- The levee system,
- Flood control economics, and
- Upper watershed flood control.

Activities that could result in potentially significant impacts include:

- Changing Delta hydraulics;
- Converting leveed lands to tidal marsh/slough complexes;
- Constructing setback levees;
- Connecting dead-end sloughs;
- Constructing overflow basins;
- Modifying levee and berm vegetation management practices on waterside of levees;
- Flooding selected islands;
- Obtaining conservation easements or purchasing land for riparian habitat restoration;
- Developing tidal wetlands;
- Physically changing structures, such as bridge abutments, diversion dams, and water intakes;
- Improving fish passage;
- Preserving or restoring 50- to 100-year floodplains;
- Restoring riparian habitat;
- Removing existing dams or diversions; and
- Increasing flood control cost, or reducing flood control economic benefits by 100% or more.

ASSESSMENT METHODS

The discussion of assessment methods is separated into three sections: flood management operations, levee systems, and flood control economics. The flood management operations discussion focuses on the flood control system's ability to handle flood flows under the project alternatives from a conveyance and storage perspective. The analysis of the levee system focuses on the system's ability to handle the flood flows from a structural perspective. The economics of flood control involves the comparison of flood control benefits with flood control costs.

Flood Management Operations

Potential flood control impacts on storage and conveyance facilities are analyzed separately. This approach provides a consistent basis for comparing alternatives with variable storage and conveyance facilities, although it may overlook or minimize some minor synergistic effects between such facilities.

For CALFED actions that generally involve north Delta modifications, the North Delta Program Environmental Impact Report/ Environmental Impact Statement (EIR/EIS) (DWR 1990b) was reviewed. Flows and elevations from the 1984 flood and a predicted 100-year flood were analyzed. For the south Delta modifications, the Interim South Delta Program (ISDP) EIR/EIS (Entrix 1996) was reviewed.

To provide an additional measure of the relative importance of CALFED actions to flood control, data on large flood events in the Sacramento and the San Joaquin rivers were used. For the

Sacramento River, daily flow data from the February 1986 flood were used (Hydrodata 1997). For the San Joaquin River, daily flow data from the floods of 1980, 1983, and 1997 were used (Hydrodata 1997). For each alternative, proposed additions to storage were compared to the measured flood flows for these large events. These comparisons then were used to determine whether the additional storage proposed for each alternative would substantially increase flood management capabilities relative to expected flood flows.

Simulated changes in conveyance capacity resulting from channel widening were analyzed using the U.S. Army Corps of Engineers (Corps) HEC-RAS model (Corps 1995a). This model simulates water surface elevations for a given channel geometry and flow rate. Using this model, different channel configurations in the alternatives were compared to the base case to determine whether these configurations would significantly change conveyance capacity in the potentially affected channels.

Levee System

Potential impacts on the levee system were assessed using the best available information, which includes cited and referenced commercial and scientific literature, and interviews at meetings with geotechnical specialists. These meetings were used to develop the existing conditions and No Action Alternative trends, and to identify potential impacts and mitigation strategies. Meetings were attended by representatives of the California Department of Water Resources (DWR), U.S. Bureau of Reclamation (Reclamation), the Corps, U.S. Fish and Wildlife Service (USFWS), and others.

Flood Control Economics

Flood control economics benefits are damages and losses avoided in the future from implement flood control actions. Flood control costs are those necessary to implement and maintain the project under evaluation. Costs are generally well determined for specific flood control projects after engineering design studies have been completed. Benefits must be estimated, however, because they depend on the improved performance of the levee to prevent future damages to agriculture soils and crops, and buildings or facilities—the timing and severity of which also must be estimated.

Direct flood control economics benefits include avoided:

- Damages to soils, crops, buildings and their contents;
- Damages to infrastructure;
- Functional losses, including building rent;
- Business income losses; and
- Loss of public and nonprofit services.

Future benefits are estimated over the useful lifetime of the flood control project and discounted to present values.

Values for most parameters used to indicate the economic condition of the flood control system were presented in the Affected Environment Technical Report for Flood Control.

Values that are not routinely published, such as land values by use, contents values, and infrastructure values, were assigned values derived by using the cost of reproducing a unit of that parameter. The values are preliminary and were derived only for illustrative purposes for this analysis.
Procedures for the economic assessment of flood control impacts include:

- An inventory and estimated values of land, crops, buildings, associated uses, and infrastructure;

- Estimates of the effectiveness of the project to reduce damages and functional losses; and
- Estimates of the flood risk associated with the project.

Secondary economic benefits also result from flood control projects when local firms purchase production inputs and sell products to other firms in the region. Indicators of secondary benefits (and costs) are changes in related asset values, incomes, employment, and population. Secondary economic benefits and costs can be calculated using existing data after direct economic impacts have been estimated.

SIGNIFICANCE CRITERIA

California Environmental Quality Act

The California Environmental Quality Act (CEQA) Guidelines state that a project will normally have a significant effect on the environment if it will:

- Cause substantial flooding, erosion, or siltation (CCR, Title 14, Appendix G[q][1995]);
- Interfere with emergency response plans or emergency evacuation plans (CCR, Title 14, Appendix C[z][1995]);
- Expose people or property to water-related hazards, such as flooding (CCR, Title 14, Appendix I[IV][b][1995]); or
- Generate the need for new or altered government servcies, specifically the maintenance of public facilities (CCR, Title 14, Appendix I[XI][D][1995]).

National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires consideration of both the context and intensity of an environmental impact when determining its significance (40 CFR Part 1508.27). Impact analysis is framed within a regional context. Intensity refers to the severity of an impact, and includes consideration of the following when analyzing flood management system impacts:

- Both beneficial and adverse impacts (40 CFR Part 1508.27[b][1]);
- The degree to which the action may affect public health and safety (40 CFR Part 1508.27[b][2]);
- The degree to which the effects on the quality of the human environment are likely to be highly controversial (40 CFR Part 1508.27[b][4];
- The degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks (40 CFR Part 1508.27[b][5]);
- The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration (40 CFR Part 1508.27[b][6]); and
- Whether the action threatens a violation of federal, state, or local law or requirements imposed for the protection of the environment (40 CFR Part 1508.27[b][10]).

Both the regional impact context and these intensity considerations were used in detemining whether a CALFED action could result in a significant environmental impact for either flood management operations, the levee system, or with respect to flood control economics.

The description of flood management system impacts are qualitative because of the general level of definition of the programmatic alternatives. Since this evaluation is still at the programmatic stage, an impact on flood management system operations is considered significant if it has the potential to either: (1)

raise flood stage elevations, or (2) increase the frequency of flooding. Actions are considered to have less than significant impacts on flood management system operations if they do not substantially raise flood stage elevations, or increase the frequency of flooding.

For the levee system, an action was considered potentially significant if implementing a CALFED would substantially increase:

- Seepage;
- Island subsidence;
- Levee settlement;
- Wind erosion;
- Flood stage hazards (by reducing freeboards—that is, the vertical distance between the normal maximum water level and the top of the levee, which represents the added level of flood protection provided by that portion of the levee that extends higher than the maximum expected stage or water level for which the levee was designed);
- Scour; or
- Sedimentation.

An impact on the levee system also was considered potentially significant if implementing a CALFED action would substantially decrease:

- Levee stability;
- Inspection, maintenance, or repair capabilities;
- Levee slope protection;
- Emergency response capabilities;
- Channel capacity; or
- The ability of levees to withstand seismic loading.

Flood control economics criteria can be used to judge the significance of physical changes to the environment. Costs and expected benefits are described for each alternative, and quantified where possible. Changes that exceed 10% in either costs of flood control or expected benefits are considered potentially significant for this analysis.

Values for the significant flood control parameters were projected for the "No Action Alternative" and the three proposed alternatives. These values were then used to develop the expected annual cost of levee failure and the annual cost of flood protection. The expected annual cost of levee failure is an indication of potential flood control benefits assuming that the levee system is 100% effective to the design elevation. The annual cost of flood protection represents the level of effort with the assumption that levees would be effective to their designed level of effectiveness. An annual cost of $15 million is used. If the flood protection program was 100% effective, the benefit cost ratio for the program could be calculated by dividing the annual potential benefits by the annual cost.

Potentially significant impacts of flood control actions on other resource categories, such as agricultural resources, are described in the technical reports for those resources.

ENVIRONMENTAL CONSEQUENCES

Table 1 provides a summary of potential impacts on flood control in regions that would be affected by CALFED programs. Table S-1 in the Supplement compares impacts on flood control parameters for existing conditions, the No Action Alternative, and CALFED Configurations.

Comparison of No Action Alternative to Existing Conditions

DELTA REGION

Under the No Action Alternative, continued deterioration of the levees and hence diminished

Existing Conditions	Alternatives: No Action	1	2	3
Delta Region				
Current level of protection varies. Assuming protection to 1 in 33 years, annual expected losses to land and property up to $320 million.	Increased value of land and property in the Delta. Level of flood protection slightly less than for existing conditions. Annual expected losses to land and property up to $400 million.	Potentially large benefits from levee improvements and Delta channel modifications. Expected annual losses reduced to $140 million compared to $400 million under No Action Alternative. Large annual costs to construction and maintenance.	Similar to Alternative 1. Delta channel improvements provide additional benefits.	Similar to Alternative 1. Isolated conveyance facility and channel improvements could provide additional benefits.
Sacramento Region				
Existing level of protection varies from less than 30 years to more than 100 years flood protection.	Potential increased level of flood protection resulting from ongoing programs. Increased value of resources at risk of flooding.	Small potential benefits or costs to flood control from reoperation for Ecosystem Restoration Program flows and from diversion of flows to off-stream storage. Potential flood control benefit downstream of off-stream storage site.	Similar to Alternative 1.	Similar to Alternative 1.
San Joaquin Region				
Existing level of protection varies from less than 30 years to more than 100 years of flood protection.	Potential increased level of flood protection resulting from ongoing programs. Increased value of resources at risk of flooding.	Small potential benefits or costs to flood control from reoperation for Ecoystem Restoration Program flows and from diversion of flows to off-stream storage. Potential flood control benefit downstream of off-stream storage site.	Similar to Alternative 1.	Similar to Alternative 1

Table 1. Summary of Potential Impacts on Flood Control

ability to handle flood flows is expected. Existing funding, physical trends, and environmental trends are expected to continue affecting the levee system in the future. Other flood control projects and expected earthquake activity also are considered for the No Action Alternative.

FUNDING

Maintenance of the flood control system remains an ever-present challenge. As with other public infrastructure, funding is inadequate to eliminate the maintenance backlog. The inadequacy of funding is expected to continue. The inability to compete for limited funding could cause some participants to delay or forego paying for levee repairs. As more participants delayed repairs, more levees could deteriorate, resulting in decreases in overall levee system stability and integrity. It is likely that some islands with less valuable resources could not be reclaimed if they became flooded due to levee failures.

Much of the immediately foreseeable levee improvement funding is expected to be spent for levee stability and habitat improvements to protect valuable economic, water quality, and habitat resources. Some of this immediate funding could be used on the western Delta islands that DWR considers important for protecting valuable resources. Levees surrounding western Delta islands protect major Delta channels in the area where freshwater and saltwater mixes. Levee failure and island flooding could result in undesirable saltwater intrusion and other adverse water quality impacts.

In other locations, funding could be adequate to improve existing levees or to construct new ones. For example, levee assessments and funding may increase in areas where urbanization rates continue to grow. Levees could be eligible for federal funds as part of cost-sharing for post-flood assistance if they have been: (1) maintained to the Public Law (PL) 84-99 criteria requiring that levees be restored to the level of protection provided prior to a flood event, and (2) approved prior to a flood that has been declared a national disaster.

The actual locations where funds are expended for flood management system maintenance and improvements depend on future state and federal policies and priorities regarding relative values of Delta resources. These policies and priorities require balancing Delta community, ecosystem, economic, land use, infrastructure, water supply, and water quality resource values because limited funds are apportioned for levee improvement and maintenance work.

PHYSICAL TRENDS

Physical processes cause gradual deterioration of levees and/or increased pressures on the levees. These processes include subsidence and settlement, erosion from waves and current scour, and internal levee and foundation erosion. Each of these processes could lead to an increased risk of levee overtopping and stability failures, especially during flood events.

Island subsidence due to peat oxidation and consolidation increases the effective height of levees and the water pressure on levees. As subsidence continues under the No Action Alternative, the ability of the levee system to handle peak flows would be increasingly jeopardized. Long-term settlement of levees due to ongoing consolidation or migration of foundation soils, especially peat, would reduce the levees' crest elevation and therefore the freeboard. Scour and erosion could cause loss of levee material. If supporting material was lost at the base or water-side "toe" of a levee side slope, stability failures could result. Internal erosion, frequently exacerbated by "pipes" created by animal burrows and decaying tree roots, also could lead to instability or overtopping.

Twenty-seven Delta levee failures were recorded from 1967 to 1992 (DWR 1993b). Twenty-six of these failures occurred during major floods. About half resulted from overtopping, and half from stability failures. This trend is expected to continue if maintenance and repair funding allocations remain inadequate.

Delta dredging is limited to 45 days—August 1 to September 15—during summer because of regulatory constraints and species considerations, making the Delta a limited source of dredged borrow material. Future Delta dredging was assumed to be limited to short summer periods because of regulatory requirements.

ENVIRONMENTAL TRENDS

Coordinated habitat restoration efforts would probably would continue. Senate Bill (SB) 1065, enacted in 1991 (Cal. Water Code §§ 12306, 12307), required habitat protection as part of levee maintenance work. SB 1065 directed future mitigation associated with levee maintenance to result in no net long-term loss of habitat. California Water Code Section 12987(d) requires the California Department of Fish and Game to make a written determination, as a part of its review and approval of the plan or project, that program expenditures are consistent with a net long-term habitat improvement program and have a net benefit for aquatic species in the Delta.

Urbanization pressures from the perimeter of the Delta Region could continue. Residents and users of new developments could accelerate levee deterioration through increased access, boat wake-induced erosion, and vandalism (for example, unauthorized recreational driving on levee slopes, or disturbance or removal of rock protection). As urbanization continues in and around the Delta and near its tributary streams and rivers, runoff is expected to increase. Increasing runoff could lead to increased river stage in the Delta.

OTHER FLOOD CONTROL PROJECTS

Interim Reoperation of Folsom Dam and Reservoir. The overall effect of the interim reoperation of Folsom Dam and Reservoir on the Delta flood control system is beneficial. Interim reoperation delays the timing of flood flows and consequently reduces the possibility that flood peaks from the American River watershed could reach the Delta at the same time. Interim reoperation of Folsom Dam and Reservoir could continue to require release of more water than usual in fall to create reservoir space for spring runoff from the American River watershed. The ability of Folsom Dam and Reservoir to detain a much greater volume of runoff than has been historically possible under traditional flood curve operating criteria is important. During a flood, detention allows flood managers to maintain safer flows on the American River through the City of Sacramento to its confluence with the Sacramento River.

Sacramento River Flood Control Project Evaluation. The Sacramento River Flood Control Project consists of a vast system of levees, overflow weirs, outfall gates, pumping plants, leveed bypass floodways, and over-bank floodway areas (Corps 1995b). Levee reconstruction along the Sacramento River and the Colusa Basin Drain could reduce the risk of flood stage hazards in the Delta Region. However, some accidental upstream levee failures have acted as beneficial safety valves by unintentionally causing the release of waters before they otherwise could have flooded the Delta. After these accidental upstream releases, the reduced flow volume in the Sacramento River channel resulted in lower flood stages and hazards in the Delta. Future flood risk hazards in the Delta therefore could increase if upstream levee repairs were made at these "safety valve" locations before repairs were made to downstream Delta levees.

EXPECTED EARTHQUAKE ACTIVITY

The United States Geological Survey (USGS) recently concluded that a large magnitude earthquake has a high probability of occurring in the San Francisco Bay Area within the next 30 years. This conclusion and the occurrence of the Loma Prieta Earthquake in 1989 intensified concerns relating to the stability of levees in the Sacramento-San Joaquin Delta. (DWR 1992.)

DWR has provided preliminary assessments of the susceptibility of Delta levees to damage from future earthquakes, and an evaluation of the opportunity for that damage to occur (DWR 1992). The basis for these assessments is found in a review of the pattern of regional faulting near the Delta (DWR 1992). According to a recent Reclamation report (Ake et al. 1991) most of the late Quaternary faults in the Central California Coast Range Region and near the Delta can be considered part of the San Andreas Fault System. Therefore, the Delta could be affected from an earthquake caused by the San Andreas Fault System. The Delta also lies astride the boundary zone between the Coast Ranges and the Great Valley, which according to Ake et al. (1991), is believed to be a compressional boundary with a zone of thrust faulting, reverse faults, and folding.

As discussed immediately above, the Delta therefore is subject to seismic activity from several faults. In general, seismicity consists of two factors: the level of shaking and its duration. Increases in damage result from earthquakes with both a high level of shaking and a relatively long duration. If one factor is decreased, earthquake damage is reduced.

DWR (1992) used these and other fault characteristics and data to briefly describe each fault that might be expected to affect the seismicity of the Delta. The San Andreas Fault System has the most potential of all regional faults to affect Delta seismicity. The Hayward Fault is closer to the Delta and has the second highest potential to affect Delta seismicity, with perhaps a slightly decreased level of shaking than could result from the San Andreas Fault. Other faults, including the Healdsburg-Rogers Creek Fault, the Maacama Fault, and the Green Valley-Cordelia and Concord faults could affect Delta seismicity to a much lesser level of shaking or duration.

FLOOD CONTROL ECONOMICS

The real value of land, buildings, and related contents is estimated to increase by 25% in all use categories by the year 2020 (see Table 2). This increase is based on extrapolation of recent trends in land uses, including increased orchard and vineyard acreage and more intensive residential, commercial, and recreational uses. The value of wetlands and open water habitats, and annual expected flood losses also are projected to increase by 25%. The annual cost of flood prevention, which is measured in the State Subvention Program expenditures, was assumed to remain constant.

To illustrate how flood control economics would be affected by the Levee System Integrity Program, the 2020 No Action Alternative condition of levees in the Delta was assumed to provide protection against the one in 33-year flood event. This level of protection probably is lower than provided under existing conditions; however, continued subsidence and deterioration of the levee system would occur between now and 2020. This level of protection means that in any given year, an average Delta island will have about a 3% chance of levee failure and inundation.

It is possible that some levee failures could occur between now and the 2020 No Action condition and that some of the failures would be judged uneconomical to repair. In this event, the value of property remaining to protect in 2020 would be reduced. In addition, because the less reliable levees are likely to fail first, the average reliability of remaining levees probably would increase.

BAY REGION

Current and No Action Alternative flood control resources are, with few exceptions, located upstream of the Bay Region and would not affect flood control in the Bay Region.

SACRAMENTO RIVER AND SAN JOAQUIN RIVER REGIONS

The Sacramento River and San Joaquin River regions include a large amount of flood-prone lands upstream of the statutory delta on the Sacramento and San Joaquin rivers and their tributaries. Assessments of flood control needs and potential actions have recently been conducted by the Corps. It is anticipated that some or many of these actions will be undertaken between now and the year 2020 under the No Action Alternative, but specific projects and their impacts on flood control economics have not been identified. Therefore, some improvement in flood control protection and reduction of risk is likely between now and 2020.

Concurrently, the real value of resources susceptible to flood damage is expected to increase. Trends causing the increase include the long-term shift toward permanent and vegetable crops, continued residential and other

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urban development, and increased demand for recreational and environmental resources. Costs of flood protection are also expected to increase.

The Sacramento River and San Joaquin River regions contain a wide range of flood control resources, including levees, weirs, bypasses, and reservoirs.

Most levees are part of state and federal programs. Under the No Action Alternative, current maintenance and repair policies are assumed to continue through the year 2020; therefore, levees can be expected to perform adequately through 2020. Failures may occur during this period, but failures would be due to

Flood Control Economics Parameter	Existing Conditions		No Action Alternative	
	Assumption	Value ($)	Assumption[a] (%)	Value ($)
Residential land values	5k acres @ $20k per acre	100,000,000	25	125,000,000
Commercial land values	2k acres @ $30k per acre	6,000,000	25	7,500,000
Industrial land values	6k acres @ $10k per acre	60,000,000	25	75,000,000
Irrigated land	465k acres @ $3k per acre	1,395,000,000	25	1,743,750,000
Non-irrigated land	90k acres @ $1k per acre	90,000,000	25	112,500,000
Residential building and contents values	5k acres @ $200k per acre	1,000,000,000	25	1,250,000,000
Commercial building and contents values	2k acres @ $300k per acre	600,000,000	25	750,000,000
Industrial building and contents values	6k acres @ $100k per acre	600,000,000	25	750,000,000
Agricultural building and contents values	550k acres @ $750 per acre	412,500,000	25	515,625,000
Infrastructure value	60k acres @ $100k per acre	6,000,000,000	25	7,500,000,000
Native vegetation	35k acres @ $1k per acre	35,000,000	0	35,000,000
Riparian and wetland vegetation	100k acres @ $3k per acre	300,000,000	0	300,000,000
Open water	90k acres @ $3k per acre	270,000,000	0	270,000,000
Expected annual cost of levee failure	3% of total value	317,955,000	25	397,443,750
Annual cost of flood protection	Average State Subvention Program costs in Delta	10,000,000	0	10,000,000

[a] The real value of land, buildings, and related contents was assumed to increase by 25% in all use categories by 2020.

Table 2. Value of Potentially Affected Resources in the Delta Region under the No Action Alternative

the unpredictability of nature, and performance would not differ substantially from existing conditions.

Levees in the Sacramento River and San Joaquin River regions are subjected to five forces that affect their performance: settlement, slope stability, overtopping, seepage, and erosion. In general, these forces can be handled through the currently authorized maintenance and emergency response mechanisms.
Weirs and bypasses are regulated by federal and state agreements, and would continue to operate under the No Action Alternative as they do today.

Likewise, reservoirs are covered under a variety of federal, state, and cooperative agreements that ensure their effective operation through 2020.

SWP AND CVP SERVICE AREAS OUTSIDE THE CENTRAL VALLEY

The performance of the flood control resource under the No Action Alternative could have an adverse effect on the SWP and CVP Service Areas Outside the Central Valley. As discussed under comparison of No Action Alternative to Existing Conditions for the Delta Region, the flood control system in the Delta could continue to deteriorate under the No Action Alternative. Depending on the actual circumstances, deterioration of the floodway, which is also the conveyance for water to SWP and CVP facilities, could reduce or interrupt the quantity and/or quality of water supplied outside the Central Valley.

Comparison of CALFED Alternatives to No Action Alternative

DELTA REGION

ALL ALTERNATIVES

Ecosystem Restoration Program

Impacts attributable to the Ecosystem Restoration Program (ERP) could occur under all project alternatives.

In the Delta Region, the Ecosystem Restoration Program consists of 22 resource elements, each with one to five specific action items. The resource elements were evaluated for their potential to substantially affect flood control (Table S-2 in the Supplement). Actions that could result in potentially significant impacts on flood management operations and capabilities include the following:

- Delta channel hydraulics,
- Floodplain inundation and sediment detention, and
- Riparian scrub habitat restoration.

The following beneficial impacts are associated with implementation of the Ecosystem Restoration Program in the Delta Region.

Increased channel capacity as a result of setback levee construction. The construction of new setback levees would increase the conveyance of selected Delta channels. Table 3 presents an example of the impacts of setback levees on channel capacity. The capacity of three example channel sizes, 50-, 100-, and 300-foot bottom widths, were estimated with and without setback levees. Table 3 generally indicates that benefits are greatest for initially smaller channels.

Reduced peak flood flows downstream of overflow basins. The construction of overflow basins and conversion of leveed lands to wetlands would reduce peak flood flows to areas downstream of the overflow basins. The sizes of the overflow basins have not been determined; therefore, the reduction in flood flows cannot be estimated.

However, given the high volume of flooding that has occurred in the north Delta, substantial beneficial impacts on the flood management system would require the conversion of several Delta islands to overflow basins. For example, during the flood of February 1986, almost 4 million acre-feet (MAF) of water passed Freeport in the Sacramento River. More than 1 MAF of flow passed Freeport during the five highest flow days (February 17 to 21).

Channel Bottom Width	Increase to Top of Levee (%)	Increase with 3-Foot Freeboard (%)
50 ft.	40	16
100 ft.	25	4
300 ft.	8	4

NOTE:

Assumes a 10-foot deep channel with a levee height of 10 feet (20-foot depth from channel bottom to top of levee) and a 100-foot setback levee on one side of channel. The values were calculated with Manning's equation for open channel flow, assuming normal depth in the channel with a Manning's "n" of 0.04. The cross-section of the channel was assumed to be trapezoidal in shape, with 2:1 (horizontal:vertical) side slopes.

Table 3. Estimated Increase in Channel Capacity with 100-Foot Setback Levee

Detaining a substantial portion of these flows would require converting many Delta islands along the Sacramento River to overflow basins. In the absence of such a major conversion, only minor beneficial reductions in flows downstream of these basins are expected.

Increased channel capacity due to channel widening and establishing floodplain areas along Delta channels. Impacts of restoring riparian corridors to flood control would be similar to those described for setback levees. Relative impacts would be somewhat minor on large channels and greater on small channels.

Increased erosion protection. Increased density of shallow-rooted grasses and vegetation could increase erosion protection on levee side slopes. Shallow roots protect levees against erosion by binding soil particles.

Reduced erosion from establishing and enforcing no wake and no motorized boating zones. Establishing and enforcing no wake boating zones would reduce wave run-up and erosion. Reduced erosion would preserve levee stability.

Reduced oxidation rates and settlement from the creation of shallow water habitat. Flooding of islands with elevations below sea level would reduce oxidation rates of peat soils, which would reduce settlement and related flood-stage hazard risks.

The following potentially significant adverse impacts are associated with implementation of the Ecosystem Restoration Program in the Delta Region.

Reduced levee inspection, maintenance, repair, and emergency response capabilities due to reduced vegetation management. Reduced pruning and clearing would allow more deep roots to penetrate levees and more dense vegetative canopies on levee surfaces. Deep roots could reduce the structural strength of levees. Dense vegetation could substantially reduce inspection capabilities by hiding rodent holes, cracks, or other potential causes of levee degradation. Thick understory vegetation also would limit access to levee side slopes, thereby reducing maintenance, repair, and emergency response capabilities.

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Reduced levee stability caused by deep-rooted shrubs and trees established as part of the habitat restoration actions. Over time, deep-rooted and dense riparian trees and shrubs could increase the opportunity for roots to penetrate levees. Root activity could reduce levee stability. Increased cracking and fissures could allow water to enter the levee interior, resulting in reduced structural stability. Small cracks, fissures, and root voids could also allow increased seepage beneath the levee, which could increase levee instability.

Increased seepage due to shallow flooding. Shallow flooding of Delta islands susceptible to subsidence could substantially increase seepage, reduce the stability of adjacent levees, and cause substantial flooding due to seepage-induced failure. Water seeping beneath levees contributes to levee instability. Sandy levees are especially susceptible to seepage erosion and the resulting formation of "pipes" or large voids in the levee material (BDOC 1993). The amount of seepage would depend on soil permeability, seepage path length underneath the levee, and the height of the hydraulic head.

Wind-generated wave erosion due to island flooding. Island flooding could result in significant increases in wind-fetch and wave erosion on waterside levee slopes. Long fetches created by the flooded areas would result in larger waves being generated. These waves could substantially erode levee slopes. Impacts may not be detected until a substantial amount of levee slope material has been removed by wind-generated wave erosion.

Flood control economics. Implementing the Ecosystem Restoration Program would significantly affect the economics of flood control in the Delta and its tributaries because any change in land use directly affects the economics of flood control.

The Ecosystem Restoration Program proposes to restore up to 161,000 acres of natural habitats to the Delta. If agricultural land was converted to natural habitat, the economic benefits of flood control would decline, because less economic value would be at risk after the conversion, according to conventional cost-benefit analysis usually done as part of flood control evaluations. If the conversion of agricultural land to natural habitat is accompanied by a reduction in the level of flood protection for nearby lands with higher economic values, there may be minor economic impacts associated with the cost of providing flood protection equivalent to existing conditions prior to land conversion. Although detailed information regarding land and water management practices under the Ecosystem Restoration Program is currently unavailable, such economic impacts would be prevented by coordinating habitat conversions and levee upgrades (under the Levee System Integrity Program) to ensure that potentially affected economic values near lands converted to natural habitat are provided some level of flood protection after conversion equal to that level existing before conversion.

Currently, sufficient information about land and water management in Ecosystem Restoration Program lands is unavailable to make quantitative estimates of effects on flood control economics.

Water Quality Program and Coordinated Watershed Management

The following beneficial impact is associated with implementation of the Water Quality Program in the Delta Region. This impact could occur under all alternatives.

Slight flood control benefits from urban and industrial runoff control measures. Design of storm drainage systems targeting maximum stormwater infiltration or stormwater sedimentation facilities would beneficially affect the Delta flood control system. Increased detention and infiltration would reduce the volume of surface flooding. Although stormwater basins would not detain substantial volumes of flood waters, their storage function could slightly reduce local flood stage hazard risks.

Levee System Integrity Program

Impacts described in this section apply to the Delta Region under all alternatives.

The Delta Levee System Integrity Program would provide long-term protection for Delta resources by maintaining and improving the integrity of the Delta levee system. Another objective of this program is to integrate ecosystem restoration and levee improvements. Some system vulnerability problems and the actions needed to correct them are well understood, whereas other problems require more research. Implementation of this program would require reliable, long-term funding that distributes the costs of assuring levee system integrity among all beneficiaries.

The Delta Levee System Integrity Program has five elements, including the:

- Delta Levee Base Level Protection Plan,
- Delta Levee Special Improvement Projects,
- Delta Island Subsidence Control Plan,
- Delta Levee Emergency Management Plan, and
- Delta Levee Seismic Risk Assessment.

The Delta Levee Base Level Protection Plan would use existing programs to increase the extent of Delta project and non-project levees that meet minimum federal flood control performance criteria. Local reclamation districts would provide the primary source of resources for maintaining and improving the Delta levee system, with increased state and federal participation and resources. Policy-related actions might include definition of minimum levee maintenance requirements; minimum levee improvement design criteria; ongoing levee maintenance and improvement funding requirements; and local cost-sharing plans, and a phasing sequence for all program actions. Physical actions with the potential to improve the levee system might include seepage and erosion control, levee stability improvements, and flood conveyance improvements.

The Delta Levee Special Improvement Projects would provide increased flood protection beyond the Delta Levee Base Level Protection Plan for Delta islands with many public benefits. Overall priorities for planning levee improvements would be based on a ranking of how well levees or islands protect one or more of the water quality, agricultural production, life and personal property, cultural resources, recreation, ecosystem, or infrastructure functions. Physical actions with the potential to improve the levee system might include increasing levee stability and improving flood conveyance conditions.

The Delta Island Subsidence Control Plan would promote island subsidence to provide long-term reliability of Delta levees in coordination with other agencies and stakeholders. Evaluations of subsidence rates and depths of organic soils would be included in an implementation plan that will identify actions and a phasing sequence for correcting subsidence. Research-related actions might include investigations of the effects of agricultural practices on subsidence and projects demonstrating subsidence control or reduction practices.

The Delta Levee Emergency Management Plan would build on existing emergency management resources to protect critical Delta resources during an emergency. Program staff would coordinate emergency planning with other state, federal, and local agencies, and stakeholders to identify pre-emergency and post-disaster recovery measures, including planning and allocation resources prior to an emergency, developing levee repair and recovery effort criteria, and planning and allocating resources for recovery efforts.

The Delta Levee Seismic Risk Assessment would identify and increase the understanding of the seismic risks to Delta resources and develop recommendations for increasing Delta levee seismic stability. Program staff would use existing and new seismic information to identify important seismic issues and improve risk reduction planning and coordination with other agencies and stakeholders. Actions designed to improve seismic risk information might include updating seismic risk information, evaluating Delta levee seismic performance, and identifying cost-effective measures to improve the stability of Delta levees.

The following beneficial impacts are associated with implementation of the Levee System Integrity Program.

Reduced maintenance and repair backlogs due to improved levee stability. Raising levee heights, widening levee crowns, flattening levee slopes, and constructing stability berms as part of the Delta levee base level protection and special improvement plans would improve Delta levee system stability. With improved stability, more levees would meet federal flood control project criteria, thereby qualifying them for federal repair and emergency response funding. As more levees qualified for federal funding assistance, maintenance and repair backlogs could be reduced.

Reduced levee erosion and seepage. Providing slope protection, relocating irrigation ditches, and installing drainage systems or slurry cutoff walls as part of the Delta levee base level protection plan would improve Delta levees by reducing erosion and seepage. Implementing these actions in compliance with uniform levee maintenance criteria and uniform guidelines for habitat enhancement and protection would reduce degradation of the levee system and prevent long-term habitat loss.

Reduced levee instability and overtopping failures. Improving channel configurations for flood flows, constructing cutoff levees, and creating bypass systems consistent with Delta levee special improvement projects would benefit system flood conveyance capacity by allowing flood inflows to safely pass into the Delta. Improved flood flow conveyance capacity into the Delta would reduce the incidence of instability and overtopping failures in the north Delta.

Increased levee stability as a result of the subsidence control plan. Purchasing conservation easements adjacent to levees and reducing the intensity of agricultural practices near landside levee slopes as part of the Delta island subsidence control plan would improve levee stability by reducing subsidence. Easements and less intense agricultural practices, as non-structural improvements to the flood control system, would have no adverse impacts on ecosystem restoration activities.

Reduced levee vulnerability to catastrophic failure. Preparing updated flood risk assessments and arranging for advance equipment contracts, participation agreements, and levee repair materials as part of the Delta Levee Emergency Management Plan would improve flood control system integrity by reducing the vulnerability of levees to catastrophic failure. Improved emergency preparedness through multi-agency participation would minimize the extent and severity of flood damage and thereby reduce post-disaster recovery funding needed from Federal Emergency Management Agency and other disaster-relief agencies.

Improved understanding of Delta levee performance during an earthquake. Preparing updated seismic risk assessments and ground motion mapping, and performing dynamic testing of levee material properties and levee stability analysis would improve the understanding of Delta levee performance during an earthquake. This improved understanding would allow preliminary identification of the locations where levees may be most susceptible to earthquake damage. Understanding and identifying these levees would provide guidance for future cost-effective expenditure of funds used for strengthening levees most susceptible to failure during an earthquake.

Increased flood protection for selected islands. Habitat improvement and levee stabilization projects could be implemented on selected islands according to their potential to improve Delta water quality, agricultural production, life and personal property, recreation, cultural resources, ecosystem, infrastructure, and adjacent island functions and values. The use of a priority system could improve levee stability, increase freeboard, and reduce scour and seepage potential at important locations across the Delta Region. Existing levees could be rehabilitated and set back in some locations to make these improvements. Levee relocation could provide more stable foundation and construction, resulting in reduced subsidence, settlement, and seepage. Setting levees back from channels could reduce wave run-up and seepage.

Water Use Efficiency Program and Water Transfers

No action items in the Water Use Efficiency Program would significantly affect the flood control system in the Delta Region under any alternative. Implementation of this program would not increase the chance for Delta flooding, erosion, seepage, subsidence, settlement, scour, or sedimentation. Water Use Efficiency Program actions would not reduce levee stability; inspection, maintenance, or repair capabilities; slope protection; emergency response capabilities; or channel capacity.

Water transfers could have beneficial and adverse impacts to flood control, depending on the source of water for the transfer, the timing, the magnitude, and the pathway of each transfer. If a transfer involves releasing water from a reservoir during summer months, additional space to store inflow and reduce the threat of downstream flood flows may result.

Storage and Conveyance

Storage and conveyance facilities proposed vary under each alternative and therefore are described separately below. No new water storage or conveyance facilities are included in Configuration 1A. Table 4 lists potential impacts of Alternative 1 Storage and Conveyance components. Table 5 compares

Alternative 1: Existing System Conveyance

CALFED Program Component	Expected Impact
Configuration 1A	
Sacramento-San Joaquin Delta Levees Subvention Program	Beneficial for flood control
Uniform Delta Base-Level Funding Program	Adverse impact on flood control
Special Habitat Improvement and Levee Stabilization Program	Beneficial for flood control
Subsidence control	Beneficial for flood control
Levee-associated habitat	Beneficial for flood control
Reuse of dredged material	Beneficial for flood control
Delta levee emergency response	Beneficial for flood control
Delta levee seismic susceptibility	Beneficial for flood control
Delta in-channel islands	Beneficial for flood control
Levee-associated recreation	Beneficial for flood control
Reoperation of system facilities	Beneficial for flood control
Configuration 1B	
In addition to 1A:	
South Delta flow control barriers	Beneficial for flood control
Configuration 1C	
In addition to 1A and 1B:	
Old River channel enlargement	Beneficial for flood control
3.0 MAF of storage on Sacramento River tributaries	Beneficial for flood control
1.0 MAF surface water storage in south-Delta off aqueduct	Beneficial for flood control

NOTES:

cfs = Cubic foot per second.
MAF = Million acre-feet.
TAF = Thousand acre-feet.

Table 4. Potential Impacts of Alternative 1 Storage and Conveyance Components in the Delta Region

potential benefits and cots of Alternative 1 flood protection in the Delta Region.

Alternative 1

Configuration 1B

No new water storage facilities are included in Configuration 1B.

Improvements are proposed in the south Delta that would reduce the current impact of the CVP and SWP export operations, including:

- Installing an operable barrier or equivalent at the head of Old River to maintain a positive flow in the San Joaquin River;
- Installing flow and stage control measures in the Middle River, Grant Line Canal, and Old River or other methods to control flow, stage, and south-Delta salinity;
- Installing new fish screens at the Skinner Fish facility and at the Tracy Pumping Plant intake; and
- Installing an intertie between Tracy Pumping Plant and Clifton Court Forebay.

The new fish screens and intertie are not expected to result in potentially significant impacts on flood management.

The following potentially significant adverse impact is associated with conveyance facilities. This impact also applies to all other alternatives, except Configurations 1A and 3I.

Reduced flood flow conveyance due to gate structures located in channels. The interim operable barrier at the head of the Old River and the control structures on Middle River, Grant Line Canal, and Old River are similar to the alternatives described in the ISDP EIR/EIS. These controls would not be operated during periods of high flow in the San Joaquin River. However, the gate structures located in these channels could reduce their flood flow conveyance, resulting in increased stage upstream of the structures and possibly decreased stage downstream. The amount of increase (or decrease) would depend on the final design of the structures.

Configuration 1C

Configuration 1C would add new storage and conveyance facilities to Configuration 1B, including enlargement of Delta channels. New storage facilities potentially would be constructed outside the Delta, including:

- 3 MAF of surface water storage upstream of the Delta in the Sacramento Valley,
- 1 MAF of off-aqueduct surface water storage (south of the Delta),
- 250 thousand acre-feet (TAF) of groundwater storage in the Sacramento Valley, and
- 500 TAF of groundwater storage in the San Joaquin Valley.

The following beneficial impact is associated with storage facilities in the Delta Region under Configuration 1C. This impact also applies to Configurations 2B, 2E, 3B, 3E, 3H, and 3I.

Incidental flood storage. The only storage option with potential beneficial impacts on flood control in the Delta would be the 3 MAF of additional surface storage in the Sacramento Valley. Groundwater and off-aqueduct storage would not capture and attenuate substantial stormwater runoff flows significantly, and therefore would not affect flood flows.

Flood Control Economic Parameter	Configuration 1A		Configuration 1B		Configuration 1C	
	Assumption[a] (%)	Value ($)	Assumption[b] (%)	Value ($)	Assumption[b] (%)	Value ($)
Residential land values	5	131,250,000	0	131,250,000	5	137,812,500
Commercial land values	10	82,500,000	2	84,150,000	5	86,625,000
Industrial land values	5	78,750,000	2	80,325,000	5	82,687,500
Irrigated land	-20	1,395,000,000	10	1,534,500,000	15	1,604,250,000
Non-irrigated land	-50	56,250,000	10	61,875,000	15	64,687,500
Residential building and contents values	5	1,312,500,000	0	1,312,500,000	5	1,378,125,000
Commercial building and contents values	10	825,000,000	0	825,000,000	5	866,250,000
Industrial building and contents values	5	787,500,000	0	787,500,000	5	826,875,000
Agricultural building and contents values	5	541,406,250	0	541,406,250	5	568,476,563
Infrastructure value	5	7,875,000,000	0	7,875,000,000	5	8,268,750,000
Native vegetation	50	127,500,000	10	140,250,000	10	140,250,000
Riparian and wetland vegetation	100	750,000,000	10	825,000,000	10	825,000,000
Open water	10	371,250,000	10	408,375,000	10	408,375,000
Expected annual cost of levee failure	3 to 1% chance of flood	143,339,063	3 to .99% chance of flood	144,610,599	3 to .98% chance of flood	149,530,008
Possible flood control benefits		254,104,688		252,833,151		247,913,742
Annual cost of flood protection	50	15,000,000	0	15,000,000	0	15,000,000

[a] Change from No Action Alternative.
[b] Change from Configuration 1A.

Table 5. Potential Benefits and Costs of Alternative 1 Flood Protection in the Delta Region

It was assumed for the purpose of this analysis that the 3 MAF of additional storage would be divided equally among environmental, agricultural, and water supply uses. Storage available for flood control would be incidental only (that is, storage not being used for other purposes and available when a storm occurred). If only a small amount of storage was available for flood control, flooding in the Delta would not be substantially reduced.

To provide a qualitative estimate of the potential benefits of the additional storage to the Delta flood control system, flows from the February

1986 storm in the Sacramento Valley were reviewed. Table 6 shows the flow volumes in the Sacramento River and its main tributaries from February 15 to 19, when the peak flow occurred at Freeport.

For each river, flows in excess of 200 TAF per day were recorded for at least 1 day during the peak of the flood. Three MAF of additional storage would have resulted in only a minor benefit to these tributaries, because the amount of storage would have been relatively small compared to the daily flow volumes (greater than 200 TAF) and because flood control storage would have been incidental to other dedicated uses.

Construction of roads, structures, or other facilities within stream channels could result in increased potential for downstream flooding if the construction activity reduces the carrying capacity of the channel but does not provide an adequate mechanism for controlled release of resulting impounded water. This impact is not expected to be significant because the construction design would include flow diversion and control structures at dams and stream crossings.

A dam failure could result in severe flooding. However, this is not considered to be a significant impact because storage projects would be constructed and operated to reduce the potential for dam failure to less than significant levels.

Date	Upper Sacramento River at Butte City (# 11389000)	Feather River near Gridley (# 11407150)	Yuba River near Marysville (# 11421000)	American River near Fair Oaks (# 11446500)	Sacramento Weir Spill to Yolo Bypass (# 11426000)	Sacramento River at Freeport (# 11447650)
2/15/86	174,942	35,702	18,149	40,066	103	127,140
2/16/86	243,967	64,860	37,488	52,959	1,083	161,653
2/17/86	224,132	128,331	127,140	158,876	98,777	194,579
2/18/86	257,851	251,901	183,868	245,950	195,570	214,215
2/19/86	281,653	289,587	200,331	259,950	241,983	228,099
Total	**1,182,545**	**770,381**	**566,976**	**757,801**	**537,516**	**925,686**

NOTE:

"#" = U.S. Geological Survey gaging station number.

Table 6. Volumes of Flow in Sacramento River Valley during the February 1986 Storm Event (in acre-feet)

Flood Control Economics. The Ecosystem Restoration Program and Levee System Integrity Program would have a significant effect on the economics of flood control in the Delta and its tributaries. Any change in land use directly affects the economics of flood control.
The Ecosystem Restoration Program proposes to restore up to 161,000 acres of natural habitat to the Delta. If agricultural land is converted to natural habitat, the benefits of flood control will decline because less value is at risk, and land and channel modifications may affect water elevations, flow rates, levee break locations, and other factors that influence flood damages. On the other hand, changes in land use may change flood control risks. For example, increased open water in the delta might decrease the pressure of a given flood event on the levee system. Currently, not enough information about land

and water management on Ecosystem Restoration Program lands exists to make any quantitative estimates.

The Levee System Integrity Program proposes to fund levees to the PL-99 standard, which calls for a level of protection to the 100-year flood. The Levee System Integrity Program also contains provisions for subsidence control in the Delta. These programs are assumed to reduce the annual risk of floods from levee failure. This would increase flood control benefits, but higher annual flood protection costs of maintaining the improved levees would result. Exact costs have not been estimated at this time.

The Levee System Integrity Program proposes special habitat improvements, a levee associated habitat program, and levee associated recreation. These programs will decrease the amount of agricultural land, and the value of commercial buildings and related contents may be increased from the No Action Alternative.

Configuration 1C includes new water storage facilities. The exact locations of these facilities are unspecified, but it is expected that they will provide some minor flood control benefit to the Delta Region.

Most of the benefits of flood control are embodied in the provisions of the Ecosystem Restoration Program and Levee System Integrity Program with the specific objective to improve all levees to PL-99 standards. Generally, Alternative 1 is projected to increase the acreage of native vegetation, riparian and wetland habitat and open water at the expense of agricultural land. The values of commercial, industrial, and residential land are projected to increase slightly due to improved flood control effectiveness.

The installation of flow control barriers is projected to increase the value of agricultural, industrial, and commercial land values resulting from improved water quality (Configuration 1B), increasing the value of flood control. A slight improvement in flood control effectiveness is also possible.

Configuration 1C includes new water storage reservoirs. New reservoirs may provide flood control benefits downstream if space is dedicated for flood control, and some benefit may occur even without dedicated space. However, four potential reservoirs are located off-stream in relatively small watersheds, so flood control benefits would be relatively small.

Due to minimal in-Delta conveyance facility changes, conveyance capacity would continue to be the principle limiting factor to water transfers. The number and magnitude of water transfers would continue to be relatively small, except in dry years. The Water Transfer Program would influence only a fraction of Central Valley and Delta flows, generally increasing base flows but not exacerbating high flows. There would continue to be potentially significant effects on a transfers. These effects would be slightly increased from conditions under the No Action Alternative. Existing laws and regulations, such as NEPA, CEQA, the SWRCB's policy to not approve transfers with unreasonable environmental effects(Water Code Sections 1025.5(b), 1725, 1736), and the CVPIA(PL 102-575) are adequate to mitigate environmental effects of water transfers expected under Alternative 1.

Alternative 2

Table 7 compares potential impacts of Alternative 2 water storage and conveyance impacts in the Delta Region. Table 8 compares potential benefits and costs of Alternative 2 flood protection.

Configuration 2A

No new storage facilities are planned under Configuration 2A.

Improvements in conveyance would be

Alternative 2: Modified Through-Delta Conveyance	
CALFED Program Component	**Expected Impact**
Configuration 2A	
New 10,000-cfs Hood intake structure	Beneficial for flood control
North Fork Mokelumne River setback levees	Beneficial for flood control
South Fork Mokelumne River levee breach and protection of interior levee slopes	Beneficial for flood control
New setback levees and breaching levee of McCormack-Williamson Tract	Beneficial for flood control
Opening channel to Snodgrass Slough	Beneficial for flood control
New setback levees 500 feet from existing Mokelumne River levee and removing existing obstructing levee	Beneficial for flood control
Configuration 2B	
In addition to 2A:	
500,000 acre-feet San Joaquin River storage	Beneficial for flood control
2.0 MAF of south-Delta off-aqueduct surface water storage	Beneficial for flood control
Configuration 2E	
In addition to 2A:	
Conversion of Bouldin Island to aquatic habitat	Beneficial for flood control
Setback levees on Old River	Beneficial for flood control
Flooding tracts along the eastern side of the South Fork Mokelumne River	Beneficial for flood control
Eask Mokelumne River Floodway	Beneficial for flood control

NOTES:
cfs = Cubic foot per second.
MAF = Million acre-feet.

Table 7. Potential Impacts of Alternative 2 Storage and Conveyance Components on Flood Control in the Delta Region

provided between the Sacramento and Mokelumne rivers along Snodgrass Slough. The conveyance of the Mokelumne River from Interstate 5 to the San Joaquin River would be increased by setting back the existing levees on one side of the channel by 500 feet.

Configuration 2A is similar to the preferred alternative analyzed in the North Delta Program EIR/EIS (DWR 1990b). In addition to setting back the levees 500 feet along one side of the North Mokelumne River, the North Delta Program alternative also included channel enlargements. The North Delta Program alternative would result in significant reductions in 100-year flood stages throughout the north Delta area. The North Delta Program EIR/EIS analysis included simulated levee breaks. Reductions in the 100-year stage varied from about 2.9 to 4.5 feet at New Hope Landing, with decreasing impacts moving downstream. At the confluence of the North and South forks of the Mokelumne River, no difference was predicted.

The following beneficial impacts are associated with conveyance facilities in the Delta Region under Configuration 2A.

Reduced flood stage due to levee setback on the Mokelumne River. This impact also applies to Configurations 2B, 3A, 3B, 3E, and 3I. A HEC-RAS model of the Mokelumne River using flow and cross-section data from the North Delta EIR/EIS was used to determine whether levee setbacks alone would result in the benefits obtained from north Delta improvements. The HEC-RAS results indicate that about half the reduction in flood stage reported in the North Delta Program EIR/EIS is due to the levee setback and about half is due to the dredging of the North Fork Mokelumne River. Based on these HEC-RAS results and the North Delta EIR/EIS model results, the 100-year flood stage is expected to be reduced by about 1 to 2 feet near the McCormack-Williamson Tract due to the proposed levee setback alone. At the confluence of the North and South forks of the Mokelumne River, the North Delta Program assumed no significant reduction in flood stages. The same benefits would apply to Configuration 2A (and 2B, 3A, 3B, 3E, and 3I).

Flood Control Economics Parameter	Configuration 2A		Configuration 2B	
	Assumption[a] (%)	Value ($)	Assumption[b] (%)	Value ($)
Residential land values	5	131,250,000	0	131,250,000
Commercial land values	10	82,500,000	0	82,500,000
Industrial land values	5	78,750,000	0	78,750,000
Irrigated land	-20	1,395,000,000	15	1,604,250,000
Non-irrigated land	-50	56,250,000	0	56,250,000
Residential building and contents values	5	1,312,500,000	0	1,312,500,000
Commercial building and contents values	10	825,000,000	0	825,000,000
Industrial building and contents values	5	787,500,000	0	787,500,000
Agricultural building and contents values	5	541,406,250	0	541,406,250
Infrastructure value	5	7,785,000,000	0	7,875,000,000
Native vegetation	50	127,500,000	0	127,500,000
Riparian and wetland vegetation	100	750,000,000	0	750,000,000
Open water	10	371,250,000	0	371,250,000
Expected annual cost of levee failure	3 to .95% chance of flood	136,172,109	3 to 1% chance of flood	145,431,563
Possible flood control benefits		261,271,641		252,012,188
Annual cost of flood protection	50	15,000,000	0	15,000,000

Flood Control Economics Parameter	Configuration 2D		Configuration 2E	
	Assumption[b] (%)	Value ($)	Assumption[b] (%)	Value ($)
Residential land values	0	131,250,000	0	131,250,000
Commercial land values	0	82,500,000	0	82,500,000
Industrial land values	0	78,750,000	0	78,750,000
Irrigated land	20	1,674,000,000	20	1,674,000,000
Non-irrigated land	0	56,250,000	0	56,250,000
Residential building and contents values	0	1,312,500,000	0	1,312,500,000
Commercial building and contents values	0	825,000,000	0	825,000,000
Industrial building and contents values	0	787,500,000	0	787,500,000
Agricultural building and contents values	0	541,406,250	0	541,406,250
Infrastructure value	0	7,875,000,000	0	7,875,000,000
Native vegetation	0	127,500,000	0	127,500,000
Riparian and wetland vegetation	0	750,000,000	0	750,000,000
Open water	0	371,250,000	0	371,250,000
Expected annual cost of levee failure	3 to .9% chance of flood	131,516,156	3 to .9% chance of flood	131,516,156
Possible flood control benefits		265,927,594		265,927,594
Annual cost of flood protection	0	15,000,000	0	15,000,000

[a] Change from No Action Alternative.
[b] Change from Configuration 2A.

Table 8. Potential Benefits and Costs of Alternative 2 Flood Protection in the Delta Region

Increased conveyance capacity on Old River. This impact applies also to Configurations 2B, 2D, 3A, 3B, 3E, 3H, and 3I. South Delta modifications include channel enlargement along a 4.9-mile reach in Old River; an operable barrier at the head of Old River; and flow and stage control on Middle River, Grant Line Canal, and Old River. These modifications are similar to alternatives described in the ISDP. Enlargement of the Old River channel would increase the conveyance capacity of the channel, which could result in some localized reductions in flooding.

The following potentially significant adverse impacts are associated with Configuration 1C.

Reduced flood flow conveyance due to gate structures located in channels. Impacts of the flow and stage control structures were discussed under Configuration 1B.

Configuration 2B

Configuration 2B would add new storage facilities to Configuration 2A. The new storage facilities are the same as those described for Configuration 1C, with two additions: 500 TAF of surface water storage upstream of the Delta on San Joaquin tributaries and an increase in off-aqueduct storage to 2 MAF. The increase in off-aqueduct storage would not affect flood flows in the Delta because the storage would not be located onstream where it could temporarily detain flows. The additional 500 TAF of storage on the San Joaquin River tributaries is expected to benefit flood control, as described below.

The following beneficial impact is associated with Configuration 2B. This impact also applies to Configuration 2D and 2E.

Increased flood storage. Flow data were reviewed for the storm that occurred from December 1996 to January 1997 at Vernalis and Gravelly Ford on the San Joaquin River. The data were reviewed to quantitatively estimate the impacts on flood control of an additional 500 TAF of storage designated for environmental, urban, and agricultural purposes. During the peak of this storm (from January 3 through 6), about 130 TAF were released from Millerton Reservoir, which reached its peak storage and inflow on January 3. If 100 TAF of additional storage had been available, flood flows downstream of Millerton Reservoir would have been reduced significantly. If a significant percentage of the 500 TAF was available for flood storage on the San Joaquin River, significant flood control benefits could be achieved. Because the additional storage is not designated for flood control, its availability cannot be guaranteed, and flood control benefits may not be realized.

Configuration 2D

Up to 2 MAF of off-aqueduct storage is proposed south of the Delta. As discussed for Configuration 2B, off-aqueduct storage would provide little flood control benefit because off-stream storage could not temporarily detain flows. In addition, this storage would be dedicated to uses other than flood control.

Configuration 2D includes channel modifications to the South Fork of the Mokelumne River to increase conveyance, setback levees along Old River to increase conveyance to Clifton Court Forebay, and construction of an operable fish barrier at the head of Old River.

The beneficial and adverse impacts on flood management of increasing conveyance along Old River and construction of an operable fish barrier were discussed under Configuration 2A. Beneficial impacts associated with the setback levees are discussed below.

Increased floodplain width and reduced stage due to construction of setback levees on the South Fork Mokelumne River. Configuration 2D includes several sets of setback levees. On the South Fork Mokelumne River, these include 2,000-foot setbacks to the east on New Hope and Terminous tracts, and a 4,000-foot setback to the west on Staten Island. These setbacks would significantly increase the floodplain width and result in lower flood stages.

In general, the discussion of the effects of 500-foot setback levees under Configuration 2A also apply to Configuration 2D. However, since the setbacks for Configuration 2D would be significantly wider, flood water surface elevations are expected to drop further. Given a flow of 34,400 cfs—the peak flow during the 1986 flood event in the North Fork Mokelumne according to the 1990 North Delta Program EIR/EIS—the flood stage may drop:

- An additional 1 foot below the 500-foot setback level with 2,000-foot setbacks, and

- An additional 1½ feet with 4,000-foot setbacks.

Increased conveyance capacity and reduced water surface elevations as a result of new flooded habitat. Portions of levees along the Canal Ranch and Brack tracts and Bouldin Island would be removed to flood the islands and provide new flooded habitat.

In addition to increasing conveyance capacity on the South Fork Mokelumne River, the levee setback and levee removal alternatives would lower local water surface elevations and reduce peak flows. Reductions in peak flow rate could range from 5 to 10%. Local water surface elevations could drop from 2 to 4 feet relative to existing conditions. Water surface elevations a few miles upstream also would be reduced.

Levee setbacks and removals would have two additional impacts. First, lower water surface elevations would result in a steeper hydraulic gradient and higher flow velocities immediately upstream of the levee removal location. The maximum increase in these velocities is expected to be about 1 to 2 feet per second. Second, lower water surface elevations would change the flow distribution, possibly increasing the volume of water that discharges through the South Fork Mokelumne River.

Configuration 2E

Configuration 2E is similar to Configuration 2D, with the addition of:

- Increased conveyance along Georgiana Slough from Sacramento River to the weir intake into the central Delta,
- Flooding of Tyler Island, and
- Introduction of storage facilities.

As with Configuration 2D, breached levees are expected to significantly reduce flood levels only if they provide flow conveyance and storage. Additional storage is not anticipated to provide significant flood benefits. Therefore, the flooding of Tyler Island and McCormack-Williamson Tract, Bouldin Island, and tracts along the eastern side of the South Fork Mokelumne River would provide only limited flood control benefits, as they would reduce peak flow rates but are not expected to significantly lower water surface elevations. For example, the DWOPR modeling of the north Delta (DWR 1990b) indicated that during the 1986 flood, water levels dropped 1 foot when the Tyler Island levee breached, probably due to the available storage on Tyler Island. This storage would not have been available had the Tyler Island levee been breached and flooded before the peak flow rates arrived, however, as would be the case for the islands flooded under this alternative.

Conveyance facilities under Configuration 2E are similar to those in Configuration 2D, with the addition of increased conveyance along Georgiana Slough from the Sacramento River weir intake into the central Delta. The setback on Georgiana Slough would not affect flows downstream.

Changes in conveyance capacity may affect water surface elevations and flow splits. As with Configuration 2D, the overall effect would be the reduction of peak water surface elevation at, and upstream of, the levee removal location. The setback on Andrus Levee, coupled with the absence of setbacks on New Hope Tract, and, to a lesser extent, Terminous Tract, would alter flow splits between the North and South forks of the Mokelumne River. When compared to Configuration 2D, Configuration 2E would result in more water flowing to the North Fork and proportionately less to the South Fork Mokelumne River.

Flood Control Economics. Proposed north Delta improvements include a shallow channel integrated with Snodgrass Slough, flooding McCormack-Williamson Tract, and installing setback levees on the New Hope Tract (Tyler, Staten, and Bouldin islands) to improve through-channel water flows. These changes may impact the economics of flood control by reducing the amount of agricultural land. The South Delta Improvements should not affect the economics of flood control.

Configurations 2B, 2D, and 2E are thought to increase the value of agricultural land due to more abundant irrigation water and better flood control.

The impacts of Alternative 2 on the economics of flood control are similar to Alternative 1 since both alternatives call for improving the levee systems to PL-99 standards. Alternative 2 also proposes changes to the amount of open water, riparian and wetland vegetation, and irrigated land; however, these changes do not impact significantly on the economics of flood control.

New reservoirs in Alternative 2 could provide additional flood control benefits downstream from the reservoir location; however, these benefits have not been quantified.

Alternative 3

The variations of Alternative 3 affect the economics of flood control in the Delta differently. Annual flood control benefits range from $260 to $280 million (Table 9).

New reservoirs in Alternative 3 could provide additional flood control benefits downstream of the reservoir location. These benefits are not quantified or included in estimates but could range from minor to potentially significant.

Table 10 identifies expected impacts for Alternative 3 water storage and conveyance components—all components are expected to benefit flood control.

Configuration 3A

No new storage facilities are planned under Configuration 3A.

Configuration 3A includes conveyance options that are part of the north and south Delta modifications described for Configuration 2A. In addition, a 5,000-cfs open-channel isolated facility from Hood or Freeport on the Sacramento River to Clifton Court Forebay is included, with siphons under all major stream crossings. The isolated facility could affect flood control and management in two ways. First, if it was operated during flood events and if it removed a significant volume of water from the Sacramento River and efficiently conveyed the water around the Delta, it could reduce the level of flooding downstream. Second, depending on how the facility is constructed, the facility could act as a dam to flood flows from the east.

To determine the impacts of an isolated facility on reducing Sacramento River flood flows, average daily Sacramento River flow data were used to estimate the flow rates for storm events of various magnitudes. Storm events are classified according to their frequency—that is, how often they can be expected occur. The larger a storm even, the less frequent its occurrence. For example, a storm that can be expected every 10 years is much less severe than one that occurs only once every 100 years. The interval between such storms—either 10 or 100 years for these two examples—is referred to as the particular storm's "return period."

The following potentially significant adverse impact is associated with Configuration 3A.

This impact also applies to Configurations 3B, 3E, 3H, and 3I.

Increased flooding east of the proposed isolated facility. The isolated facility would run west of, and roughly parallel to, Interstate 5. For much of its length, the isolated facility would be routed through areas not prone to frequent flooding. However, it would run through New Hope Tract, which flooded in 1986 when a levee on the Mokelumne River failed near Thornton. If the isolated facility was constructed to prevent flood flows into, over,

Flood Control Economics Parameter	Configuration 3A		Configuration 3B	
	Assumption[a] (%)	Value ($)	Assumption[b] (%)	Value ($)
Residential land values	5	131,250,000	0	131,250,000
Commercial land values	10	82,500,000	0	82,500,000
Industrial land values	5	78,750,000	0	78,750,000
Irrigated land	-20	1,395,000,000	30	1,813,500,000
Non-irrigated land	-50	56,250,000	0	56,250,000
Residential building and contents values	5	1,312,500,000	0	1,312,500,000
Commercial building and content values	10	825,000,000	0	825,000,000
Industrial building and contents values	5	787,500,000	0	787,500,000
Agricultural building and contents values	5	541,406,250	5	568,476,563
Infrastructure value	5	7,785,000,000	0	7,875,000,000
Native vegetation	75	148,750,000	0	148,750,000
Riparian and wetland vegetation	125	843,750,000	0	843,750,000
Open water	20	405,000,000	0	405,000,000
Expected annual cost of levee failure	3.0 to 0.9% chance of flood	130,343,906	3.0 to 0.85% chance of flood	126,889,926
Possible flood control benefits		267,099,844		270,553,824
Annual cost of flood protection	50	15,000,000	0	15,000,000
Residential land values	0	131,250,000	0	131,250,00
Commercial land values	0	82,500,000	0	82,500,000
Industrial land values	0	78,750,000	0	78,750,000
Irrigated land	30	1,813,500,000	30	1,813,500,000
Non-irrigated land	0	56,250,000	0	56,250,000
Residential building and contents values	0	1,312,500,000	0	1,312,500,000
Commercial building and contents values	0	825,000,000	0	825,000,000
Industrial building and contents values	0	787,500,000	0	787,500,000
Agricultural building and contents values	5	568,476,563	5	568,476,563
Infrastructure value	0	7,875,000,000	0	7,875,000,000
Native vegetation	0	148,750,000	0	148,750,000
Riparian and wetland vegetation	0	843,750,000	0	843,750,000
Open water	0	405,000,000	0	405,000,000
Expected annual cost of levee failure	3.0 to 0.8% chance of flood	119,425,813	3.0 to 0.9% chance of flood	134,354,039
Possible flood control benefits		278,017,938		263,089,711
Annual cost of flood protection	0	15,000,000	0	15,000,000
Residential land values	0	131,250,000	0	131,250,00
Commercial land values	0	82,500,000	0	82,500,000
Industrial land values	0	78,750,000	0	78,750,000
Irrigated land	-10	1,813,500,000	0	1,813,500,000
Non-irrigated land	-10	56,250,000	0	56,250,000
Residential building and contents values	0	1,312,500,000	0	1,312,500,000

Table 9. Potential Benefits and Costs of Alternative 3 Flood Protection in the Delta Region (Page 1 of 2)

Flood Control Economics Parameter	Configuration 3A		Configuration 3B	
	Assumption[a] (%)	Value ($)	Assumption[b] (%)	Value ($)
Commercial building and contents values	0	825,000,000	0	825,000,000
Industrial building and contents values	0	787,500,000	0	787,500,000
Agricultural building and contents values	5	568,476,563	5	568,476,563
Infrastructure value	0	7,875,000,000	0	7,875,000,000
Native vegetation	0	148,750,000	0	148,750,000
Riparian and wetland vegetation	0	843,750,000	10	928,125,000
Open water	0	405,000,000	0	405,000,000
Expected annual cost of levee failure	3.0 to 0.9% chance of flood	129,281,414	3.0 to 0.95% chance of flood	134,643,965
Possible flood control benefits		278,017,938		258,799,785
Annual cost of flood protection	0	15,000,000	0	15,000,000

[a] Change from No Action Alternative.
[b] Change from Configuration 3A.

Table 9. Potential Benefits and Costs of Alternative 3 Flood Protection in the Delta Region (Page 2 of 2)

under, or around it (for example if it has levees adjacent to it to prevent the entry of stormwater runoff), the facility could act as a dam during similar flooding events, which could cause increased flooding east of the facility and lengthen the time needed for pooled water to drain after the flood wave passes.

Configuration 3B

Configuration 3B is the same as Configuration 3A, except it also includes:

- New storage upstream of the Delta in the Sacramento and San Joaquin tributaries,
- Off-aqueduct storage south of the Delta (200 TAF of in-Delta storage), and
- Increased groundwater storage.

The impacts of new storage were discussed for Configurations 1C and 2B. The only new storage added in Configuration 3B is the 200 TAF of in-Delta storage.

The in-Delta storage is not allocated for flood control and is small relative to the amount of flood flows that pass through the Delta during large storm events. It is, therefore, not expected to significantly affect flood management.

Configuration 3E

Configuration 3E is similar to Configuration 3B except that the capacity of the isolated facility would be 15,000 cfs instead of 5,000 cfs and the variation does not include the Old River enlargement and barrier.

The following beneficial impact is associated with Configuration 3E.

Lowered flood flows during relatively small floods. Withdrawing 15,000 cfs from the Sacramento River could lower flood flows for small floods (10-year floods and smaller) but would not significantly affect large floods (100-year floods and larger). If 100-year flood flows downstream of Hood or Freeport could be reduced by 15,000 cfs, they would be equivalent to about a 20-year flood event, which could still

Alternative 3: Dual Delta Conveyance	
CALFED Program Component	**Expected Impact**
Configuration 3A	
5,000-cfs isolated facility (open channel) from Hood to Clifton Court Forebay	Beneficial for flood control
North Delta channel modifications	Beneficial for flood control
South Delta channel modifications	Beneficial for flood control
Changes in basic operating procedures	Beneficial for flood control
Configuration 3B	
In addition to 3A:	
3.0 MAF surface water storage on Sacramento River	Beneficial for flood control
500,000 acre-feet surface water storage on San Joaquin River	Beneficial for flood control
2.0 MAF surface water storage off-aqueduct south of Delta	Beneficial for flood control
200,000 acre-feet in-Delta storage	Beneficial for flood control
Changes in basic operating procedures	Beneficial for flood control
Configuration 3D	
In addition to 3B:	
5,000-cfs isolated facilities (18-foot pipe) from Hood to Clifton Court Forebay	Beneficial for flood control
Configuration 3E	
In addition to 3B:	
15,000-cfs isolated facility from Hood to Clifton Court Forebay	Beneficial for flood control
Configuration 3H	
In addition to 3B:	
Setback levees on New Hope Tract	Beneficial for flood control
Setback levees on Terminous Tract	Beneficial for flood control
Setback levees on Staten Island	Beneficial for flood control
Removal of portion of Bouldin Island levee	Beneficial for flood control
Configuration 3I	
In addition to 3B:	
Tyler Island aquatic habitat and flow control	Beneficial for flood control
Western 15,000-cfs isolated south-Delta intake	Beneficial for flood control
Eastern 5,000-cfs isolated south-Delta intake	Beneficial for flood control

cfs = Cubic foot per second.
MAF = Million acre-feet.

Table 10. Potential Impacts of Alternative 3 Water Storage and Conveyance Components on Flood Control in the Delta Region

cause considerable flooding under the No Action Alternative.

Configuration 3H

Configuration 3H proposes setback levees on three islands and flooding another island. These procedures would reduce agricultural acreage and reduce flood risk.

Configuration 3I

Configuration 3I would implement additional wetland habitat, and the western and eastern south Delta intakes that should reduce the risk of flood.

BAY REGION

The Ecosystem Restoration Program includes several actions that would modify flows in the Bay Region, including the establishment of shallow water habitat, open water habitat, tidal sloughs, seasonal wetlands, and riparian/shaded riverine habitat. No other program includes actions related to flooding in the Bay Region. The proposed modifications to flows in the Ecosystem Restoration Program are minor relative to the volume of water in the Bay Region.

No potentially significant impacts are associated with the implementation of the Ecosystem Restoration Program in the Bay Region.

SACRAMENTO RIVER REGION

All Alternatives

Ecosystem Restoration Program Plan

Table S-3 in the Supplement lists those Ecosystem Restoration Program resource elements related to flood control in the Sacramento River Region. Most actions are associated with improving fish migration and restoring streams to more natural conditions. The action items associated with flood management include:

- Restoring or preserving the 50- to 100-year floodplain on tributaries to the Sacramento River,
- Removing diversions and other obstructions to fish migrations,
- Vegetating or revegetating streambanks to increase riverine habitat, and
- Improving floodwater detention in the Colusa and Yolo basins.

Restoring the 50- and 100-year floodplains would provide positive flood control benefits. The level of benefit would depend on the existing flood conveyance capacities of the stream channels chosen for improvements. The protection of existing floodplains would provide no benefits over existing conditions; but to the extent that future development was prevented in the floodplain, flood benefits would be positive relative to the No Action Alternative.

The following potentially significantly adverse impacts are associated with implementation of the Ecosystem Restoration Program in the Sacramento River Region.

Increased level of flooding downstream of removed diversions. Removing diversion structures and other obstructions to flow in the Sacramento River tributaries could increase the level of flooding downstream of these diversions. The level of increase would depend on which diversions and obstructions were removed and the total number of obstructions removed. The relative increase in flooding probably would be small for large flood events (for example, a 100-year flood event) and relatively larger for small flood events (for example, a 10-year flood event). The change in flood levels would depend on how much attenuation of flood flows the existing structures provide.

Raised flood levels due to vegetation along streambanks. Vegetating streambanks could increase stages along streams due to increases in the roughness of the stream channel. On wide channels, the increase in roughness of the streambanks probably would have only a minor impact on flood stage. On small streams, the increase could be significant.

Water Use Efficiency Program and Water Transfers

Water Transfers in Alternative 1 would have a minimal effect or no effect on the Sacramento River Region.

Water Transfers in Alternative 2 would have a minimal effect or no effect on municipal water supply economics in the Sacramento River Region. Increased use of cross delta transfers by providers south of the delta might increase water transfer prices north of the delta, but Sacramento River Region providers are expected to participate very little in water transfer.

Some actions under the Water Use Efficiency Program could affect flood control in the Sacramento River Region to some degree, as described below. These impacts also apply to the San Joaquin River Region.

The following potentially significant adverse impacts are associated with implementation of the Water Use Efficiency Program in the Sacramento and San Joaquin River regions.

Levee settlement due to localized subsidence induced from groundwater pumping. Installation of on-farm efficiency improvements, such as drip and micro-irrigation systems, may require more frequent deliveries than now facilitated for surface water sources. As farmers seek to increase the frequency of their access to irrigation water, even at reduced overall volumes, they may need to pump groundwater if surface water deliveries are unavailable. Increased groundwater pumping may lead to localized ground subsidence in some areas. Pumping and subsidence occurring near levees or other flood control facilities could cause settlement of the underlying substrate, resulting in levee slumping, cracking, or related damage. The following potentially beneficial impacts are associated with implementation of the Water

Use Efficiency Program in the Sacramento and San Joaquin River regions.

Maintenance of channel capacity due to reduced sediment load from agricultural lands. Construction and installation of on-farm water use efficiency improvements, including tailwater recovery ponds or pressurized irrigation systems, could beneficially impact flood control system by reducing the volume of sediment transported to flood control channels. Tailwater recovery ponds allow sediment to settle out of the water. Pressurized irrigation systems—instead of gravity irrigation systems—typically do not generate surface runoff at rates that cause erosion. When irrigation systems are properly designed and operated, sediment remains on agricultural fields and less enters channels used to carry flood flows. As applied sediment load in the receiving channel decreases, the conveyance capacity of downstream channels is maintained. Further, a lower rate of sediment loading into these channels would require less dredging, thereby reducing flood control system maintenance costs.

Alternative 1

Configuration 1C

Storage and Conveyance

The storage and conveyance facilities proposed under each alternative vary and therefore are described separately below.

New storage facilities that could be built in the Sacramento River Region include 3 MAF of surface storage and 500 TAF of groundwater storage. No new storage would be devoted to flood control.

The following beneficial impact is associated with Configuration 1C.

Increased storage on Sacramento River tributaries. This impact also applies to Configurations 2B, 2E, 3B, 3E, 3H, and 3I. The 3 MAF of additional surface storage could provide localized flood control if it is made available when a large storm event occurs. For example, if an additional 500 TAF or more of storage had been available in 1986 on the Feather or Yuba rivers, some flooding could have been avoided (Table 11). However, because the additional storage would not be dedicated to flood control, it is considered unreliable as a flood control measure. No new conveyance facilities are proposed under Configuration 1C.

SAN JOAQUIN RIVER REGION

Table S-4 in the Supplement lists those Ecosystem Restoration Program resource elements related to flood control in the San Joaquin River Region. Most actions are associated with restoring SRA habitat, restoring the defined floodplain, and setting back levees.No Actions of the Levee System Integrity Program are targeted for the San Joaquin River Region.

All Alternatives

Ecosystem Restoration Program Plan

The following beneficial impact is associated with implementing the Ecosystem Restoration Program in the San Joaquin River Region.

Reduced flood stages due to restoration of floodplains along the San Joaquin River. Restoring the floodplains along the San Joaquin River south of Vernalis would provide flood control benefits. Presently, the probability of levee failures is high during large storm events in the San Joaquin River Region. By creatinga large floodplain, flood stages would be lowered, thereby reducing the pressure on downstream levees. The level of additional protection provided by the floodplain would depend on the size of the floodplain and its location relative to the most vulnerable levees.

The following potentially significant adverse impact is associated with implementing the

Return Period (years)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
100	93,000	90,600	83,200	87,100	71,000	54,800	32,400	25,500	27,000	26,200	76,700	90,200	83,200
20	81,600	76,900	74,400	70,500	58,700	41,800	22,700	23,500	24,650	20,700	41,800	73,300	68,200
10	73,200	71,500	69,600	63,300	48,100	33,800	20,500	20,500	21,800	18,400	27,900	64,400	53,500

NOTES:

Estimated averages are in cubic feet per second.
Flows measured at U.S. Geological Survey Gage Station No. 11447650.

SOURCE:
Hydrosphere Data Products, Inc. 1997.

Table 11. Estimated Daily Average Storm Event Flows on the Sacramento River at Freeport

Ecosystem Restoration Program in the San Joaquin River Region.

Raised flood levels as a result of allowing riparian vegetation growth. Reestablishing riparian habitat or preventing the removal of riparian vegetation would result in increasing the roughness of the stream channel and could increase flood stages. On wider channels, the increase in roughness of the streambanks would probably have only a minor impact on flood stage. On smaller streams, the increase could be significant.

Configuration 1C

Storage and Conveyance

New storage facilities that could be built in the San Joaquin River Region include 1 MAF of off-aqueduct surface storage and 500 TAF of groundwater storage. No new storage would be devoted to flood control. Because the 1 MAF of additional surface water storage would be located off-aqueduct, it would have limited ability to reduce peak storm flows.

No new conveyance facilities are proposed under Configuration 1C.

Configurations 2B, 2E, 3B, 3E, 3H, and 3I

Storage and Conveyance

Configurations 2B, 2E, 3B, 3E, 3H, and 3I include 500 TAF of surface water storage in the San Joaquin River Region, 2 MAF of off-aqueduct surface water storage, and 500 TAF of groundwater storage. No new storage would be devoted to flood control.

Also, the 2 MAF of off-aqueduct additional surface storage would have limited ability to reduce peak storm flows because it would not receive storm runoff. Only the 500 TAF of surface water storage could affect flood flows. See the discussion for Configuration 2B under Alternative 2 for the Delta Region.

No new conveyance facilities are proposed in the San Joaquin River Region under Alternative 2.

SWP AND CVP SERVICE AREAS OUTSIDE THE CENTRAL VALLEY

Because no actions are planned that would affect flood control in the SWP and CVP Service Areas Outside the Central Valley, no impacts on flood control are anticipated.

Comparison of CALFED Alternatives to Existing Conditions

The comparison of CALFED alternatives to existing conditions is the same as the comparison of CALFED alternatives to the No Action Alternative, because existing funding, physical trends, and environmental trends are expected to continue to affect the levee system under the No Action Alternative. In other words, because existing flood control conditions are expected to continue under the No Action Alternative, the effects of CALFED alternatives would be the same when compared to either existing conditions or the No Action Alternative.

MITIGATION STRATEGIES

All Alternatives

ECOSYSTEM RESTORATION PROGRAM

Implementation of one or more of the following mitigation measures could reduce impacts associated with implementation of the Ecosystem Restoration Program.

Reduced levee inspection, maintenance, repair, and emergency response capabilities due to reduced vegetation management. Reasonable clearing of deep-rooted trees and shrubs from levee side slopes should be allowed to support inspection, maintenance, repair, and emergency response, while preserving some habitat values.

Reduced levee stability caused by deep-rooted shrubs and trees established as part of the habitat restoration actions. Clearing of deep-rooted shrubs and trees on levee side slopes should be allowed. Trees and shrubs should be allowed to grow only on adjacent berms. If roots are allowed to penetrate levees, fill materials should be added to levee landside slopes in order to construct a partial setback levee and increase stability.

Increased seepage due to shallow flooding

- Locations potentially susceptible to seepage-induced failure on Delta islands that may be intentionally flooded should be identified.
- A seepage monitoring program on non-flooded islands adjacent to potential shallow-flooded islands should be implemented.
- Seepage control performance standards to be used during island flooding and storage periods should be developed to determine net seepage caused by shallow flooding.
- Levees should be improved to withstand expected hydraulic stresses and seepage.

Wind-generated wave erosion due to island flooding

- Erosion protection measures should be designed to minimize or eliminate wave splash and run-up erosion.
- Riprap or another suitable means of slope protection should be used to dissipate wave force.
- Large wind/wave breaks should be constructed in the flooded islands to reduce wind-fetch and erosion potential (large voids in the riprap relieve excess hydrostatic pressures caused by waves washing against the slope [DWR 1990a]).

These erosion protection and wave force dissipation measures should be coordinated with the Ecosystem Restoration Program to minimize adverse impacts to revegetation.

Increased level of flooding downstream of removed diversions. Streams downstream of the structure should be widened to increase conveyance capacity.

Raised flood levels due to vegetation along streambanks. Flood control criteria should be incorporated into design. For example, by increasing the width of vegetated sections to maintain conveyance capacity, the net effect of vegetation on flood control would be negligible.

LEVEE SYSTEM INTEGRITY PROGRAM

Levee rehabilitation borrow materials

- Issues regarding beneficial reuse of dredge material should be identified and investigated.
- Beneficial Bay dredge material reuse studies in the Delta for potential water quality impacts related to salinity, metals mobilization, and other environmental and health hazards should be continued.
- The cost-effectiveness and safety of using sediment traps as a source of borrow should be investigated.
- All potential sources of borrow, and the cost effectiveness of each source's use for levee rehabilitation and construction should be investigated.
- Appropriate stockpile locations and management techniques for stabilizing stockpiles against erosion should be identified.
- A borrow plan that includes future costs and options for obtaining adequate quantities of borrow needed for implementation of the Delta Levee System Integrity Program should be prepared.

WATER USE EFFICIENCY PROGRAM AND WATER TRANSFERS

Levee settlement due to localized groundwater-pumping-induced subsidence

- Existing or planned wells that could affect groundwater and substrate conditions underlying nearby levees or flood control facilities should be identified.
- Incentives to terminate use of the well, reduce its pumping volume to safe withdrawal levels as they affect substrate stability, or otherwise replace it with sources that could not affect levee stability should be provided.

Alternative 1

STORAGE AND CONVEYANCE

Reduced flood flow conveyance due to gate structures located in channels. Structures should be designed to minimize the loss of channel conveyance at the structure.

Alternative 3

STORAGE AND CONVEYANCE

Increased flooding east of the proposed isolated facility. If the isolated facility is constructed at or below ground level with no adjacent levees, it would have no impact, or only minor impacts on flooding since flows would be free to flow into or over the facility.

To the extent that the open channel canal may act to dam overland flows, a pipeline canal would have fewer impacts because it would not impede overland flows.

POTENTIALLY SIGNIFICANT UNAVOIDABLE IMPACTS

There are no potentially significant unavoidable impacts on the flood management system from implementation of the CALFED alternatives. Potentially significant impacts from Ecosystem Restoration Program actions can be mitigated by allowing levee inspection, maintenance, and repair to proceed using reasonable clearing of deep-rooted species that can reduce levee structural integrity. Other potentially significant impacts can be avoided by proper planning, engineering, and implementation.

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